Description and sensitivity analysis of a limb scattering ozone retrieval algorithm

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[1] We present the theoretical basis for an algorithm that retrieves vertical profiles of ozone concentration using measurements of light scattered from the limb of the atmosphere. Simulated radiances at wavelengths between 300 and 675 nm are inverted using the optimal estimation technique, producing a retrieved ozone number density profile between 10 and 55 km. A detailed sensitivity analysis of this ozone retrieval algorithm follows. The largest source of ozone retrieval error is tangent height misregistration (i.e., instrument pointing error), which is relevant throughout the altitude range of interest and produces retrieval errors on the order of 10–20% due to a tangent height registration error of 0.5 km. The retrieved profile is shifted in altitude relative to the true profile, with very little distortion of the profile shape. Sensitivity to stratospheric aerosol is also a significant source of error, with errors of 5–8% for altitudes less than 40 km under background aerosol conditions when an aerosol-free atmosphere is assumed by the algorithm. Using an incorrect a priori ozone estimate can produce errors up to 15% at altitudes near 10 km, but the a priori profile has little influence above that level. Addressing these error sources (e.g., with better instrument pointing knowledge, introduction of reliable aerosol information, and better instrument signal-to-noise to reduce the importance of the a priori ozone estimate, respectively) is the key to significantly improving the retrieval accuracy. Further improvement would then be limited by several secondary error sources that produce retrieval errors at the 5% level.

1. Introduction

[2] Measurements of scattered radiance in the limb of the atmosphere have been used to determine a variety of atmospheric properties, including stratospheric aerosol [*Cunnold et al.*, 1973; *Naudet and Thomas*, 1987; *McLinden et al.*, 1999], stratospheric temperature [*Rusch et al.*, 1983], mesospheric ozone concentration [*Rusch et al.*, 1984], upper-stratospheric NO_2 concentration [*Mount et al.*, 1984], and sensor attitude [*Janz et al.*, 1996; *Hilsenrath et al.*, 1997; *Sioris et al.*, 2001; *Kaiser et al.*, 2004]. The limb scatter (LS) technique has been proposed as a possible source of ozone profile information in the upper troposphere and lower stratosphere. These measurements can be made throughout the sunlit portion of the orbit, allowing global spatial coverage comparable to back-scattered ultraviolet (BUV) and thermal emission (TE) methods. LS vertical resolution is inherently lower than (but comparable to) solar occultation (SO) vertical resolution, with 1–3 km possible (depending on optical blurring), similar to TE resolution. Accurate ozone retrievals are possible throughout the stratosphere and possibly into the upper troposphere, again with performance similar to the SO and TE methods.

[3] Several groups have developed new radiative transfer (RT) models to calculate the LS radiance [*Herman et al.*, 1995; *Oikarinen et al.*, 1999; *Griffioen and Oikarinen*, 2000; *Oikarinen*, 2001; *Kaiser*, 2001; *McLinden et al.*, 2002a, 2002b; *A. Rozanov et al.*, 2002; *V. Rozanov et al.*, 2002]. A brief description of the Gauss-Seidel Limb Scattering (GSLS) RT model used in this study can be found in Appendix A of *Loughman et al.* [2004]. The body of that paper describes an intercomparison study among several RT models, which established that the GSLS model agrees well with several other methods for a variety of LS measurement conditions. However, detailed sensitivity studies are required to predict the achievable performance of the LS ozone retrieval technique. The purpose of this paper is to present the theoretical basis for a LS ozone inversion algorithm, as well as describe its sensitivity to various perturbations, in greater detail than was possible in the work of *Flittner et al.* [2000]. It must be stressed that the retrieval procedure described herein is meant to be fairly simple and generic

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